

Factors Influencing Soil and Water Conservation Adoption in Basher, Gheshnashm and Shmangus Laelai, Eritrea

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ABSTRACT

In response to widespread land degradation remarkable Soil and Water Conservation (SWC) interventions were carried out in Eritrea. Nonetheless, such interventions were not adopted by farmers and the problem still persists, hence this research was carried out from June 2015 to June 2016 to identify the factors affecting the SWC practices in Eritrea. Seventy two farm household heads were selected through quota simple random sampling and data was collected through group discussions, pair-wise problem ranking, participatory transect walks and semi-structured household questionnaire surveys. Descriptive statistics and binary logistic regression model were used for data analysis. The results indicated that only 23.61% of the respondents practice proper SWC in their farms. Moreover, the logistic regression analysis revealed that off-farm activities, land tenure insecurity, educational level of household head and household head being female had significant negative effects on SWC efforts, whereas slope of the farm showed significant positive effect. Land tenure insecurity, weak extension service and low agricultural production were also ranked by farmers as the first three constraints in SWC practices. As the legacy of the past food for work and cash for work programs, SWC is considered as a paid-work by local communities. Hence, appropriate agricultural extension, land tenure security and introduction of agro-forestry farming systems are recommended in the study area.

Key words: Binary logistic model, Eritrea, Hamelmalo, SWC interventions, tenure insecurity

Introduction

SWC has a long history in Eritrea; people have been farming for thousands of years and in parallel to that traditional conservation methods have evolved at the local level; in addition to the traditional SWC practices, during the Italian colonial period some SWC interventions including tree planting were promoted in agricultural experimental sites and near settlements, from 1922 to 1932, 1.2 million tree seedlings were planted in Eritrea [2]. Historical and archaeological evidences suggest that the Eritrean farming communities have practiced SWC for a very long period. The Safira micro-dam is a vivid witness. The magnificent soil bunds and grass strips, locally called 'Deret' literally meaning bunds, indicate that SWC practices are not new to Eritrea [20]. Between 1979 and 1992, about US\$ 116 million of food for work assistance was allocated exclusively for SWC works in Eritrea [3]. Since independence of Eritrea in 1991, through community campaigns, students summer works, national service campaigns, institutions and individuals; remarkable SWC works including hillside terracing, soil and stone bunding, tree planting, enclosures establishment, check dam and micro-dam constructions have been undertaken so as to rehabilitate degraded lands and increase the resilience of ecosystems [2,11]. From 1992 to 2014, 56,054 ha of hillsides were terraced; 7,306,745 m³ of check dams, 40,182 km of stone bunds and 46,709 km soil bunds were constructed. Reforestation has been also a major activity of the ministry of agriculture (MoA) involving both appreciable expense and labour. This has been intensified in the recent years; for instance in 2014 alone 3,628,804 tree seedlings were planted covering 1,597 ha of land with survival rate of 81%. During the same period 214,133 ha of temporary enclosures and 94,099 ha of permanent enclosures were established [20]. Despite the intended outcomes of mitigating land degradation, many of these interventions weren't adopted and maintained by farmers, many of the structures and plantations were destroyed right after the completion of projects [11]. Thus, the current study was initiated to thoroughly identify and describe the underlying causes so as to fill the information gap and contribute to the country's efforts in combating land degradation.

Materials and Methods

Description of the study sites

Basheri: Basheri village is located in zoba Anseba, sub-zoba Hamelmalo along the Keren-Nakfa road; 13 Km north of the Keren town. The area belongs to the arid lowlands agro ecological zone (AEZ) of Eritrea having an average annual rainfall of 414.13 mm (average past 15 years), potential evapotranspiration rate of 1800 - 2000 mm/year [12] and average annual temperature of 25⁰ C; with the highest mean monthly temperature of 36.2⁰ C in May and the lowest 11.0⁰ C in January [19]. Basheri village has 215 households with a total population of around 1500. Subsistence mixed farming, crop and livestock, is the main stay of the households. Sorghum, pearl millet and groundnut are the common crops grown under rainfed conditions and goats, sheep, cattle, donkeys and camels are the livestock reared in the area. Crop yields, on an average, were less than 0.7 t/ha, consequently farmers were poor. The growing season (moist period) starts in the last week of June and ends in the second week of September.

Gheshnashm and Shmangus Laelai: Shmangus Laelai and Gheshnashm villages are located in zoba Maekel, sub-zoba Serejeka along the Asmara-Keren road; the former 22 km and the latter 28 km northwest of Asmara.

These villages are located in the moist highlands AEZ of Eritrea. Records from Afdeyu, a nearby SWC research station, showed that from 1985 to 2015 the maximum and minimum annual rainfalls were 722.1 mm in 2010 and 199.8 mm in 1990, respectively. Over the same period, the average annual rainfall was 501.6 mm and the average monthly maximum and minimum temperatures were 22.80°C and 11.12°C, respectively. Gheshnashm and Shmangus Laelai had 240 and 260 households, respectively. Subsistence mixed farming system, crop and livestock, is the main stay of the households. Barley, wheat, cowpea and potato are the main crops under rainfed conditions and goats, sheep, cattle and donkey are the livestock in these areas. The growing season (moist period) starts in the last week of June and ends in the first week of September.

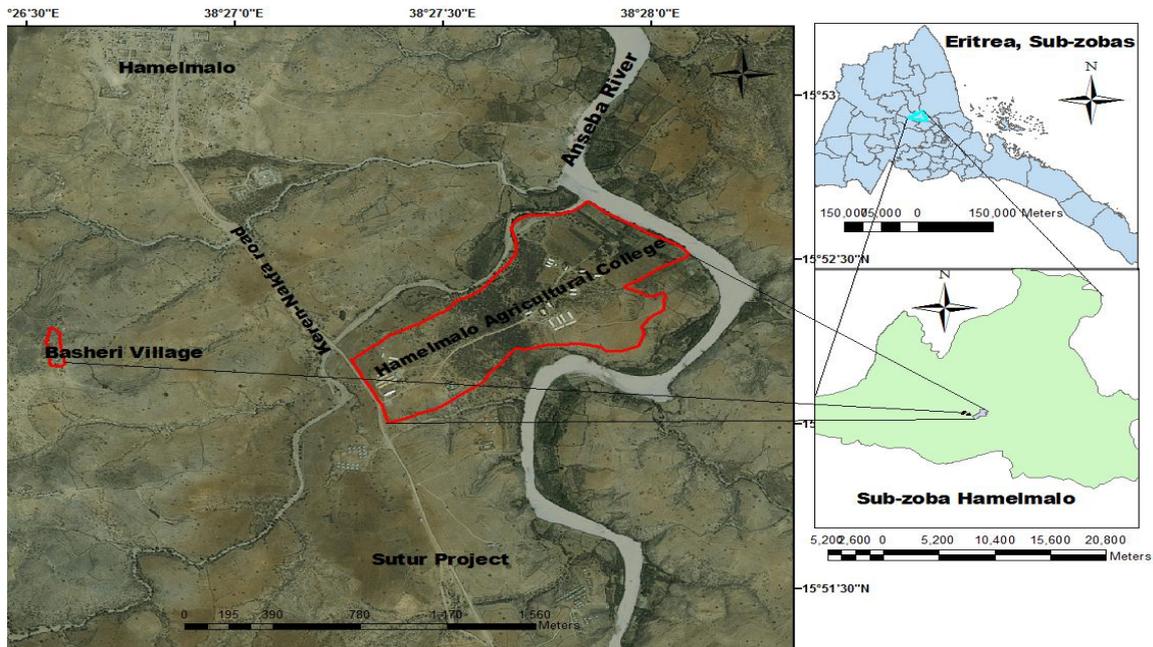


Figure 1 Location of Basherri village

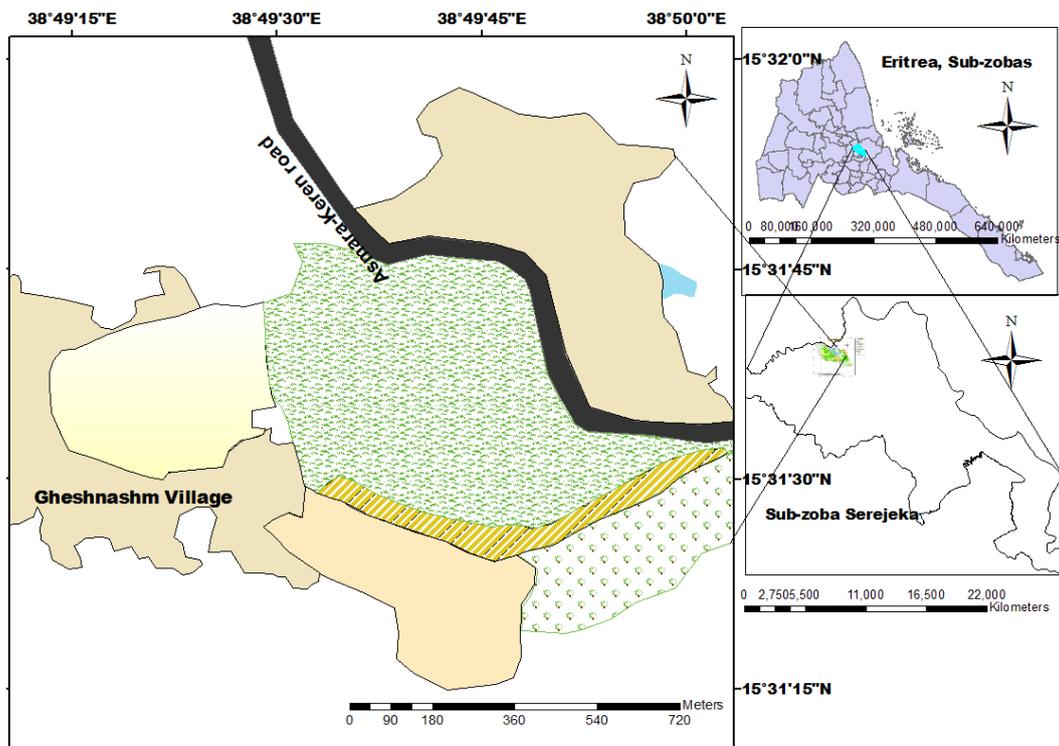


Figure 2 Location of Gheshnashm village

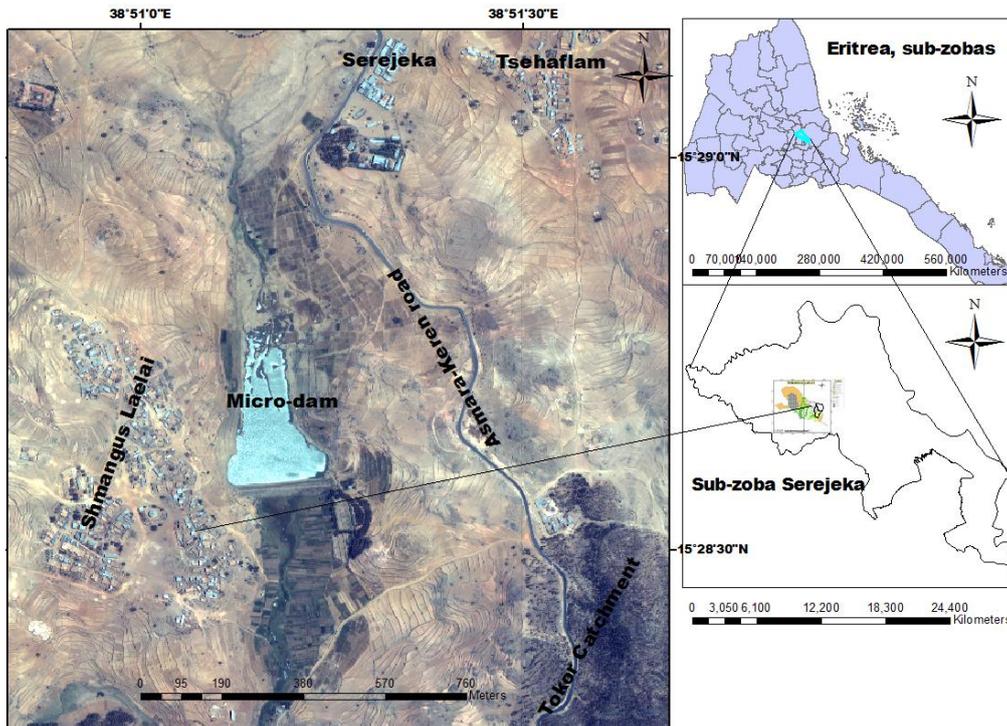


Figure 3 location of Shmangus Laelai village

Data collection and analysis

Participatory rural appraisal (PRA): PRA was used in order to help the local communities to investigate, analyse and prioritise existing problems related to SWC and seek appropriate solutions to the problems. Similar methodologies were used by different scientists [6,18]. 10% of the households were selected from each study village by quota simple random sampling method from sampling frame of separate name lists of male and female household heads. 22, 24 and 26 representative household heads were selected from Basherri, Gheshnashm and Shmangus Laelai villages, respectively.

Criteria for measuring SWC effort of a household: Criteria for measuring SWC technology adoption level of farming households may differ from project to project. But in general, an exemplary farmer is expected to apply the recommended SWC measure in his farmland, monitor it closely and maintain if it needs so and further enhance the fertility of his farmland. Considering the fact that the SWC interventions in the study areas were not full SWC packages and there were not specific SWC measures recommended, except the general objective of land rehabilitation and production increase, most of the interventions were small scale and fragmented. Thus, criteria for measuring the threshold SWC effort of a household was decided through farmers group discussions as follows:

1. First, there should be SWC measures in a household’s farmland/s; whatever the SWC measure was. In case of Gheshnashm and Shmangus Laelai, since each household had 5 small and fragmented farm plots, there should be SWC structures in all the 5 fragmented fields. In case of Basherri, as the farmland of a household was in one place only, all of the farmland was expected to have SWC measures, which could be implemented by the household, mass campaign, projects etc.
2. A household was also expected to closely monitor and maintain the SWC structures. Considering the open and heavy grazing within the study areas, all SWC structures need close checkup and maintenance at least once a year.
3. Furthermore a household was expected to enhance the fertility of its farmland; at least it has to replenish the nutrients removed by crop harvest (grain + aboveground biomass) each year. This could be done by manure and/or fertilizer application or other means.
4. A SWC effort was also expected to enhance crop production, improve food self-sufficiency, nutrition and all the living condition of a household. Thus, food self-sufficiency was also included as a requirement for the threshold SWC effort; at least a household should secure its annual food demand from its farmland.

Furthermore the participatory transect walks were planned to cover almost all the farmlands so that the adequacy and condition of SWC structures of the mentioned hard working farmers could be observed and discussed. Condition of soil erosion of a conserved farmland was taken to measure the adequacy of SWC structures for that specific field.

Each hardworking farmer, who passed the threshold level of SWC effort, gave the manure/fertilizer he/she applied each year in kg/ha/year, crop production in kg/ha, level of household income in Nakfa, improvements in household food security and household living condition in general were in scale of 1-5. This was cross checked with the household questionnaire results which were filled later on.

Binary logistic model: Farmers have accumulated knowledge of their local conditions and especially their farmlands. Farmers know what can be done to improve productivity of their farmlands but failed to do so due to different reasons [20]. In this study, the adoption of SWC practices was assumed to depend upon a set of attributes that apply to a plot of land, some of which were specific to the particular region, the village, the farm or the plot within the farm. Thus, after a thorough literature review [4,8,9,13,14,15 and 17], farmers group discussions, pair wise problems ranking, formal and informal interviews and participatory transect walks; independent variables that were expected to affect the SWC effort of a household in particular to the study sites were hypothesized (Table 1). By and large, these variables were based on the local farmers’ knowledge and experiences.

A logistic regression model that reflects the observed status of SWC effort on farmlands was selected for the reason that such observations reflect dichotomous variable, adoption or non-adoption of SWC technologies. Following [10], the logistic regression model characterizing adoption by the sample households was specified as;

$$P_i = f(\alpha + \beta X_i) = 1/[1+e^{-(\alpha + \beta X_i)}]$$

Where, subscript *i* denotes the *i*th observation in the sample, P is the probability that an individual will make a certain choice for given *X_i*, e is the base of natural logarithms, *X_i* is a vector of exogenous variables, α and β are parameters of the model, ($\beta_1, \beta_2, \dots, \beta_k$) are the coefficients associated with each explanatory variables (*X₁*, *X₂*, ..., *X_n*)

The above function can be rewritten as:

$$\ln [P_i/(1-P_i)] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + e_i$$

Where: *e* is a disturbance term and the parameters β are estimated using maximum likelihood techniques.

Specifically, the empirical model is specified as:

$$SWC_i = \beta_0 + \beta_1 GENDER_i + \beta_2 AGE_i + \beta_3 EDUCATION_i + \beta_4 SOCIAL_i + \beta_5 FAMILYSIZE_i + \beta_6 AGRILABOR_i + \beta_7 SLOPE_i + \beta_8 OFFFARM_i + \beta_9 TENUREIN_i + \beta_{10} TRAINING_i + \beta_{11} LIVESTOCK_i + e_i$$

Where: β_0 is the constant term, β_1 to β_{11} are unknown parameters to be estimated, *e* is the disturbance term.

Table 1: Independent variables that were hypothesized to affect SWC effort of a household

Explanatory Variable	Description and Unit of Measurement	Apriori Sign
X1=GENDER	Gender of the household head: 1 if the household head is male, 2 otherwise	+/-
X2=AGE	Age of the household head (years) reduced to 1-5 scale	+
X3=EDUCATION	Educational level of the household head (years)	+
X4=SOCIAL	Social position of the household head: 1 if the household head has social position in the community, 0 otherwise	+
X5=FAMILYSIZE	Family size of the household (number)	+
X6=AGRILABOR	Agricultural labour of the household (number)	+
X7=SLOPE	Average slope category of household’s farm plots: 1 flat and gentle, 2 otherwise	+
X8=OFFFARM	Off-farm activities, 1 if household head has off-farm activities, 0 otherwise	+/-
X9=LIVESTOCK	Livestock holding of a household in Tropical Livestock Unit	+/-
X10=TRAINING	Training in SWC/related area, 1 if household head is trained, 0 otherwise	+
X11=TENUREIN	Perception of household head on the negative effects of tenure insecurity in SWC effort, 5 = very bad, 4 = bad, 3 = moderate, 2 = little effect, 1= no effect	-

Results and Discussion

Descriptive statistics of the respondents

Among the surveyed household heads, 27.78% were women. The average age of the respondent household heads was 55 years, 25 being the lowest and 83 the highest, and their average educational level was grade 4, never went to school being the lowest and 12th grade the highest. Looking at the educational levels of

respondents, 23.61% had no formal education, 44.44% were elementary school (grade 1-5), 20.83% were middle school (grade 6-8), and only 11.11% reached high school (grade 9-12). None of the women respondents had attended high school classes, 65% of them were elementary school level. Only 4% of the household heads participated in agriculture related trainings during the last 10 years. Off-farm activities, mainly trade and masonry work constituted 33.33% of the respondents. The average family size was 7 with a minimum of 2 and maximum of 12 members in a family. The average agricultural labor of households was 4. The average livestock holding of the households was 3.75 Tropical Livestock Unit (TLU), with 0 minimum and 10 maximum.

According to the criteria set for a threshold SWC effort of a household only 23.61% of the respondents were found to fulfill it, which indicated that the level of SWC effort of households was very small. The results of group discussions and participatory transect walks revealed that above 90% of sloppy farmers' fields in Gheshnashm and Shimangus Lailai had old SWC structures, mostly constructed by FFW programmes and mass campaigns. In Basherri area, though SWC activities were weak, stone-walled terraces, permanent earth bunds (*Deret*), bush barriers, contour ploughing and manure application were the local SWC and soil fertility management practices. The use of crop rotation was low in Basherri, mainly due to crop failures, especially legumes, during short rains. Generally, stone-walled terraces, permanent earth bund (*Deret*) terraces, stone and earth bunds, fallowing, crop rotation, manure/fertilizer application, contour ploughing and mobile bunds were the common SWC measures that have been practiced with different degrees of use.

Factors that affect SWC effort of a household

Results of the hypothesized logistic model showed that among the 11 hypothesized explanatory variables, five variables significantly affected SWC effort of a household (at 5% level of significance). Off-farm activities (OFFFARM), tenure insecurity (TENUREIN), household head being female (GENDER), slope of a farmland (SLOPE) and educational level of household head (EDUCATION), ordered in their decreasing strength, significantly affected SWC efforts of a household. Slope of a farmland showed a positive effect but the other four variables affected SWC effort of a household negatively. Training in SWC, social position, age of household head, family size, agricultural labour and livestock holding of a household didn't show any significant effect on SWC effort of a household.

Farmers prioritized land tenure insecurity as the first most constraint in SWC effort of a household. Their argument was strongly supported by the fact that tenure insecurity showed a significant negative effect on SWC effort of a household in the logistic regression analysis. This implied that farmers have greater incentives for investing in conservation structures if they think that the time of land holding was long enough to justify and reward their investment costs. Thus, a farmer concentrates in short-term coping strategies of production decline, assuming that his/her field was going to be taken by other farmer very soon. These results were consistent with the findings of [16,17 and 21].

Farmers prioritized weak extension service as the second most constraint in SWC effort of a household. This was also supported by the developed model; training in SWC and social position of a household head are related to extension service. If a SWC trained farmer couldn't make better SWC effort than untrained farmer that means the trainings were not effective. This strongly supports the farmers' observations; as they emphasized it, the trainings were theoretical and basic.

Farmers prioritized the unattractiveness and risk-proneness of the agricultural sector as the third most constraint in SWC effort of a household. Farmers tended to look for other alternatives of income to support their family; they acted as part time farmers. This was in line with the results of the regression analysis in which off-farm activities showed significantly negative effect on SWC effort of a household. This finding contradicted with the findings of [5,7] where they reported that off-farm activities generated income and SWC investment were strengthened by that income. However, in this study's case, most of the off-farm activities of the households were meant for subsistence and often take much of household head's time that could have been used for on-farm activities.

Female being a household head showed significantly negative effect on SWC effort, as women are busy with children care, daily home works (like cooking, washing utensils etc), pregnancy time, child delivery etc, they might not had enough time to deal with SWC. Cultural barriers also restrict women from participating in SWC activities. Thus, a woman household head might not influence or manage the family so as to conserve its farmland.

Educational level of a household head had significant negative effect on SWC effort. This agreed with the findings of [8,17]. This was due to the fact that educated farmers became more cautious in their investment decisions, without tenure security they may decide not to invest in permanent conservation structures. Moreover, agriculture has not yet transformed to business, it is still in the subsistence stage. Thus, educated people might not want to apply effort in SWC, rather they preferred to look at off-farm activities taking the

advantages that their education might provide them with job opportunities. On the contrary, reference [9] found that level of education had significant positive effect on SWC effort of a household in Ethiopia.

The positive significance of slope of a farmland to SWC effort of a household illustrated the fact that farmers strengthen their SWC effort if they perceive that there was erosion in their fields. Flat and gentle plots might not show serious erosion signs, even though sheet erosion was common. Sloppy fields might develop rills very shortly due to fast running runoff along slopes; farmers easily identified this and acted to minimize the effects of erosion through SWC measures. This result was in line with the findings of [1,5,9 and 17].

Furthermore, legacy of the past FFW and CFW programmes had cultured farmers to consider SWC as an extra income-generating activity rather than incorporating it to their farming systems. This was strongly supported by [11], where the same results were found in Afdeyu, Eritrea.

Table 2: Coefficient estimates of the logistic regression analysis

Variable	B	S. E	Wald	df	Sig.	Exp (β)
GENDER	-6. 793	3.219	4.453	1	0.035*	.001
AGE	0.408	0.877	0.217	1	0.642	1.504
EDUCATION	-2. 443	1.240	3.881	1	0.049*	.087
SOCIAL	3. 173	1.986	2.552	1	0.110	23.870
FAMILYSIZE	0.403	0.891	0.204	1	0.652	1.496
AGRLABOR	0.752	0.560	1.806	1	0.179	2. 121
SLOPE	3. 452	1.669	4.280	1	0.039*	31.576
OFFFARM	-8. 964	3.717	5. 816	1	0.016*	.000
LIVESTOCK	-0.103	0.277	0.140	1	0.709	.902
TRAINING	4. 059	2. 985	1. 849	1	0.174	57. 932
TENUREIN	-6. 190	2. 684	5. 319	1	.021*	.002

Where β = regression coefficient associated with the variable, SE = standard error of the regression coefficient, Wald χ^2 test statistic, *statistically significant at 5% level

Conclusions

Throughout Eritrea in general and the highlands and midlands in particular, traditional SWC had been practised since time immemorial. With the advent of European colonial period, additional SWC measures had also been introduced to combat land degradation. However, these interventions had not yielded the desired level of result owing to a number of intermingled factors. Among the 11 independent factors studied, five of them had been identified as being significant. These were: off-farm activities, land tenure insecurity, gender, and slope of the agricultural fields and level of education of a household head. These problems were exacerbated by ineffective and inefficient agricultural extension services which resulted in poor field management and hence low agricultural production.

Recommendations

Implementation of the land reform proclamation (No.58/1994), which gives a lifelong usufruct right to land holders is vital for the adoption of SWC measures. This could favour farmer’s investment decisions towards sustainable land resources use.

The practice of SWC requires a fundamental change in the way farmers perceive and their attitude towards farming so as they consider SWC as a part of their farming system. Massive extension training could play a great role in bringing a radical change in the farmers’ knowledge, attitude and perception.

Female headed farmers need to be also empowered through training, provision of material and financial support.

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